The above is a very imperfect account of a most interesting treatise; but the fact is that in order to do more it would have been necessary to translate almost the whole work. We may add that it is written in German and that the plates furnish greatly enlarged figures of the characteristic parts of the animals described.

MISCELLANEOUS.

Preliminary Note on the Functions and Homologies of the Contractile Vacuole in Plants and Animals. By Professor Marcus M. Hartog, D.Sc., M.A.*

Through the practice of regarding botany and zoology as essentially distinct studies the solution of many an interesting problem in the one domain is long missed, because the known facts that afford a clue when properly applied have been worked out only in the other, and are contained in records never likely to be consulted in reference to the given problem. Thus the "contractile vacuole" is an organ that exists in both kingdoms: the question of protoplasmic vacuolation, of which this is a particular case, has only been really studied by the vegetable physiologist, and yet in the minute plant-cells which possess this organ it is too small for the study of the mechanism of its work; this study has been successfully carried out by zoologists on the larger Ciliata and Heliozoa, in ignorance, however, of the known facts that explained the reason of its working. Thus the botanists had forged a key of the right pattern, but too big to open the locks in their own domain, while fitting that of which the zoologists had described the wards and tumblers. In this preliminary communication I shall only put the key into the lock, reserving original observations for a complete paper.

I. *Distribution.*—One or more contractile vacuoles occur in all naked plant-zoospores, with scarcely a recorded exception, whether mastigopod or myxopod, whether Algal, Fungal (Saprolegnieæ, Peronosporeæ, Chytridieæ), or Myxomycete. They occur in all freshwater Protozoa when in the active state, though not when encysted; they are, however, absent from many of those that live in the perivisceral fluid or blood of living hosts and from the Radiolaria and possibly other marine forms.

II. *Position and Mechanism.*—They are vacuoles in the protoplasm, usually peripheral; they contract to disappearance at regular intervals; in favourable cases (*Actinosphærium*, many Ciliata) they are seen on contraction to discharge their contents into the water. In a few cases they are known to be reservoirs filled gradually by the almost continuous influx from plasmatic canals, which are invisible from this very reason, only starting into sight

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normally during the momentary pause, when, owing to the contraction of the vacuole, their liquid contents have time to accumulate and distend them.

Now if a specimen of sufficient size, say a *Paramœcium*, be placed under certain unfavourable conditions (among which is deficiency of oxygen), we find that the contractile vacuoles contract less perfectly and at longer intervals, the plasmatic canals become persistently visible and enlarged, the whole animal becomes dropsical, its thin cuticle bursts, and its protoplasm, no longer protected by the 'Hautschicht' and cuticle, and exposed directly to the water, disintegrates into "diffluence."

Again, if a vegetable cell be wounded in water and its protoplasm passes out it rounds off and surrounds itself with a Hautschicht; then vacuoles appear inside: these enlarge enormously and finally burst; the protoplasm so exposed without a Hautschicht to the water disintegrates into diffluence, just like the Ciliate whose contractile vacuole works inefficiently. This pathological vacuolation and diffluence do not occur if to the water there be added a sufficiency of sugar, saltpetre, glycerine, or other innocuous osmotic substance; and when the protoplasm has the power of excreting a complete cellulose wall, as in *Vaucheria*, the incipient vacuolation is arrested on the formation of the wall.

The explanation of both series of facts is the same, as worked out by a number of botanists from Von Mohl to De Vries:—

Protoplasm contains in its interstices substances of high osmotic value: its outer layer at least, while freely pervious to water, is slightly if at all pervious to these substances even in solution. Hence, when protoplasm is immersed in water, cavities or vacuoles form in its substance containing solutions of these substances, which continue to enlarge by attraction of water from without; the enlargement produces a tension which De Vries and others have by various methods determined to be at least three atmospheres, and which may reach fifteen atmospheres. Now, naked protoplasm has very little toughness; it yields readily to the increasing tension and to the expansion of the vacuole, and finally bursts and disintegrates. On the other hand, cellulose and chitinous cyst-walls are sufficiently tough to resist; and equilibrium is attained when, after a certain amount of stretching, the elasticity of the wall balances the tension of the vacuoles due to osmosis.

If, however, in the absence of a tough wall the vacuole, instead of extending indefinitely and bursting irregularly, (*a*) opens by a minute pore, (*b*) contracts regularly as it expels its contents, (*c*) closes up simultaneously with the completion of their expulsion,—then no part of the inner protoplasm is exposed directly to the water, and we have a mechanism which expels regularly the plasmatic juice or cell-sap when over-diluted and over-abundant, and which prevents the destruction of the protoplasm by bursting and diffluence. This is the mechanism of the contractile vacuole, which is thus a physiological necessity to the naked cell living in water, just as the kidney is to the multicellular animal organism.

I will add one unpublished observation to the well-known facts here brought together. Two sporanges of *Saprolegnia* opened at an early stage of the partial segregation of the protoplasm into masses. Part of the protoplasm in each slowly escaped and aggregated into rounded masses. The first discharged masses underwent the usual pathological changes and diffluence; the later masses (from both sporangia) had already acquired the power of forming contractile vacuoles possessed by the zoospores; the numerous small vacuoles appeared and contracted regularly, lines of separation formed and deepened, and the masses divided into zoospores, which separated and swarmed, just like the protoplasm which remained in the sporange, though more slowly. This observation seems to afford a crucial test of the truth of the thesis that the contractile vacuole has the function of preventing excessive vacuolation and diffluence of naked cells in water.

The following is a brief summary of the points on which the above thesis rests:—

1. All naked protoplasmic bodies living in fresh water have at least one contractile vacuole.

2. The possession of this is quite independent of the systematic position of the organism and of the presence of chlorophyll *.

3. The vacuole loses its contractility on the formation of a strong cell-wall or cyst, and may even disappear.

4. It is absent from Gregarinida and Opalina and the Radiolaria which inhabit saline liquids.

5. When, owing to morbid conditions, the efficiency of the contractile vacuole is impaired, excessive vacuolation and diffluence ensue.

6. Conversely, as soon as contractile vacuoles appear, the tendency to excessive vacuolation and diffluence is arrested.

It may be suggested that the perforations of the nephridial cells in Vermes and embryonic mollusks and of the epiblastic gland-cells of Vermes and Arthropods are due to the persistence of the contractile vacuole, the opening of which has become permanent, while its contractility has been superseded in the kidneys at least by other arrangements. Even the goblet-cells of mucous epithelia may possibly be traced to this origin.

On Adelphotaxy, *an undescribed Form of Irritability.*

By Professor Marcus M. Hartog, D.Sc., M.A.†

In *Achlya*, a genus of Saprolegnieæ, the zoospores lie in the sporange before liberation closely appressed together, with their long axes parallel, instead of showing the rotatory hustling movements of other species. On liberation, instead of separating and swimming

* Hence the function cannot be exclusively respiratory, though it may aid respiration.

† Read at the British Association (Bath), 1888.